University of Cincinnati

D. Caggiano, C. Hall, P. Kashinkunti, F. Khoury
R. Andreassen, Z. Huard, B. Meadows, M. Sokoloff (University of Cincinnati)
J. Rodriguez (Anderson High School)

The overall purpose of our research was to analyze data from the reconstruction of various decay chains from the LHCb experiment at CERN so that we could familiarize ourselves with the reconstruction software and layers of detectors. After we completed a tutorial of ROOT, a C++-based particle physics data analysis program that we used throughout our research, we began to work with packages of data called n-tuples from the LHCb experiment. After the data was divided into four samples based on decay chain and distributed to our group, I began to work on my own analysis. My individual exploration into the sample of data I was given included using my knowledge of physics and statistics to consider and implement "cuts" to remove unwanted background events, dividing the momentum and transverse momentum data for candidates of specific particles into five ranges with equal event populations, and generating histograms for these ranges which I filled with the candidates' mass. Next, I fit each histogram with Gaussian or double Gaussian functions to extract the mean and mean error for each of the mass plots. I then plotted the averages of the selected particle's mass versus the average of each momentum range to search for the possibility of a momentum dependency in the measurement of its mass. In one of the two decay paths I studied, B0 -> J/psi K*, this plot showed a definitive momentum dependency: the difference of the J/psi mass from the lowest momentum range to the highest momentum range was approximately 2.5 MeV/c^2. However, the masses of the two particles I closely analyzed were consistently higher than the accepted Particle Data Group mass value, ranging from 1–4 MeV/c^2. These results suggest possible issues in the reconstruction software.

D. Caggiano, C. Hall, P. Kashinkunti, F. Khoury
B. Meadows, M. Sokoloff (University of Cincinnati),
J. Rodriguez (Anderson High School)

The purpose of our research was to discover whether there is momentum dependence with the n-tuples sent from CERN. Focusing on two different n-tuples, each member of the group focused on a different series of decay paths. We focused on the D0 meson data collected by the LHCb and created ranges, or bins, containing equal number of entries to examine the reconstructed mass as a function of the momentum. We made selection cuts on the data to clean the event sample. Our selection used information from the K short masses, flight time of K short mesons and the difference in the D*+ and D0 masses. Each bin was fit with two Gaussians and a linear background term. We determined that the fits gave a good description of the data by examining the normalized residuals along the fitting range. After extracting the mean and mean error from the fits, we created an average momentum vs. average mass of the D0 meson graph. If the data ended up being on a horizontal line, then there would be no momentum dependence. The nominal mass for the D0 meson is 1864.8 MeV, but our data points ended up being in between 1865–1867 MeV, which is an acceptable margin of error that could later reveal a minor error in the data reconstruction. We discovered that there were no major fluctuations in the plot that would constitute momentum dependence because all the data plots were linear with each graph containing minor statistical error.

F. Khoury
B. Meadows (University of Cincinnati)
J. Rodriguez (Anderson High School)

In particle physics, subatomic particles possess a characteristic called the invariant mass. Invariant mass is a characteristic of the total energy and momentum of an object or a system of objects that is the same in all frames of reference related by the Lorentz transformations. With the implementation of a new hadron detector called the LHCb, it becomes important to not just understand the physics behind particle collisions but to also observe whether or not the device is reconstructing events in a correct manner. As a student researcher, I have assisted in this effort by analyzing certain decay paths that are present in the LHCb to look for momentum dependencies within the relationship of a particle's mass and momentum. The data I used for analysis was provided by CERN (The European Organization for Nuclear Research) in the form of n-tuples, which are in essence an ordered list of variables and data collected by the LHCb detector. Using ROOT programming, I was able to view this data and create mathematical relationships between different variables through the form of histograms and graphs. These graphs and histograms were used to provide a general analysis of the variables in the n-tuple and reveal whether or not they had momentum dependencies.